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# A Study to the Geometric Design of Road Project Using Civil 3D

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**ABSTRACT—**
*India is a country whose population is growing rapidly, indicating that traffic is also increases. The development of rural and Urban areas also increases its means furthering of transportation facilities are also developed. The geometric design manages the dimensions and layout of visible features of the road such as alignment, sight distance, cross-section and intersections. When geometric design performed manually, it is time-consuming and highly susceptible to very costly errors. In the present time, various software are available in market such as Bentley MX Road, HEADS, AutoCAD Civil 3D, etc are used to design the geometry of road. Current patterns are adapted to the utilization of computer programs for roadway geometry design. For this job the best available Highway Geometric Design Software must be used for designing of road. Keeping this in view we have used Autodesk Civil 3D Software for the geometric design of the proposed road. Total station is a nifty for importing the points in AutoCAD civil 3D which is in the form of x, y, z co-ordinates that is latitude, longitude and elevation. These co-ordinates of the ground will generate and helps to design the alignment in the AutoCAD.*

**KEYWORDS:-** Geometric Design, Total Station, Civil 3D, Horizontal and Vertical alignment.

## 1. INTRODUCTION

In the present trend, geometric design is an important component and having a great effect while aligning a new road. Geometric design is a backbone of any alignment of road. It deals with cross sectional elements, sight distance considerations, horizontal alignment and vertical alignment details, intersection elements and it is relaying on the important factors such as design speed, topography or terrain, traffic factors, design hourly volume and capacity, environmental and other factors. While aligning a new road, it should be short, easy, safe and economic and it is expected to be comfort and safe for the movement.
The geometric structure of the roads has three fundamental parts, which are horizontal, vertical, cross-sectional orientation. Which, when combined, give a 3-dimensional road layout. Horizontal alignment consists of three geometric components, including curves, tangents, and transitions. Vertical alignment is a longitudinal section, together with geometric additives such as crest curves, sag curves, and gradients. Highway geometry formulations depend on selection, estimated and thus act by certain design standards as sight distance, vehicle stability, driver consolation, drainage, economy, and aesthetics. Numerous Computations and Measurements

pursue design process. The civil 3D upgrade has modified this paradigm so that both design and development are carried out concurrently. When performed manually, geometrical design can be very cumbersome, time-consuming, and quite helpless to costly blunders, the traditional technique is also based, in particular, on a two-dimensional analysis that does not ensure a pleasant layout. The goal of this study is to show how geometrical design is done quickly and perfectly in a short period to enable professionals from those in the developing world to use road design. This paper shows a typical design of the highway with the support of AutoCAD Civil 3D that saves time and energy. Highway design faces tremendous challenges without 3D modeling. It consumes a lot of effort to cut and fill that amounts. The volume computing approach can be used.

## 2.SOFTWARE DESCRIPTION

AutoCAD Civil 3D is a civil engineering design and documentation tool developed by Autodesk. AutoCAD Civil 3D software supports Building Information Modelling (that is, digital representation of the physical and functional characteristics of a facility).

**i**.BIM tools for civil engineering design: AutoCAD Civil 3D supports Building Information Modeling (BIM) and helps reduce the time it takes to design, analyze, and implement changes.

**ii.** Efficient civil design: AutoCAD Civil 3D performs faster design iterations with an intelligent, 3D model-based application that dynamically updates related civil design elements when changes are made. It streamlines time-consuming tasks for corridor design, parcel design, and pressure and gravity network design.

**iii.** It improves civil drafting and documentation. Connecting design and documentation helps boost productivity and deliver higher-quality designs and construction documentation. Changes to design elements are captured in documentation, minimizing manual updates.

**iv.** GPS surveying tools for faster processing. GPS surveying and data collection tools in AutoCAD Civil 3D can help you update your processes for improved project delivery.

**v.** Integrated storm water management and geospatial analysis. AutoCAD Civil 3D helps the designer to improve project delivery and make more informed decisions using visualization, simulation, and water analysis integrated with the design process for storm water management, geospatial analysis, and model analysis.

## 3. STUDY AREA

The study area is located in NAGPUR district of NAGPUR taluk from Sahakar Nagar Ghat to Orange city Hospital Square. Length of stretch is 1.3 km. Project area passes through plain terrain and rolling terrain. Existing study area consists of asphalt road and Soil road. The alignment comprises of significant horizontal curves which would require geometric corrections.

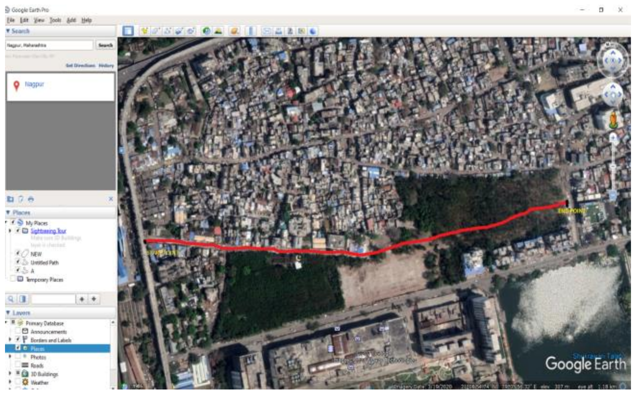



**Figure 1 – Satellite image of selected area of the Project**

## 4.DESIGN METHODOLOGY

### 4.1 DATA COLLECTION

Collecting the data and quantifying the information from a survey in the field or the study area in a systematic path in order to get proper and scrupulous picture of an area of interest, also to analyze and evaluate the outcomes and retort to the research problems. The survey data covered Easting, Northing and points elevations across the planned route.

### 4.2 SURVEYING

The survey was conducted before the typical design of project road started e.g. Location study, Reconnaissance, Preliminary, Final location survey, Map study, Reconnaissance survey, Preliminary survey, Final location. Map study is to have a rough idea of the field. Reconnaissance survey is to visit the site and scrutinize the main features of the area but not in detail. The data derived from the reconnaissance surveys are normally utilized for planning and programming the detailed surveys and investigations and few possible alignments can be chosen for any alteration or changes. In Preliminary surveys, survey specialists and party performs field surveying duties using total station and collects all data which are necessary like latitude, longitude, elevation and other required measurements and data in the alternate alignments proposed. At last, final locating the centre line of the ground.

### 4.3 TRAFFIC VOLUME COUNT

To decide the number of lanes and roadway width, pavement design, economic analysis traffic surveys are conducted. The main focus of traffic survey is to determine of vehicle composition in traffic stream which helps to design geometric features of the road.

Cumulative ESAL applications over 10 years @ 6% growth rate,

$$N = T0 \times 365 \times \frac{(1+r)n - 1}{r} \times L$$

Where,

T0 = ESAL per day = number of commercial vehicles per day in the year of opening × VDF

L = Lane distribution factor = 1 for single lane / intermediate lane.

Assuming a uniform annual growth rate “r” of 6% over the design life (n) of 10 years.

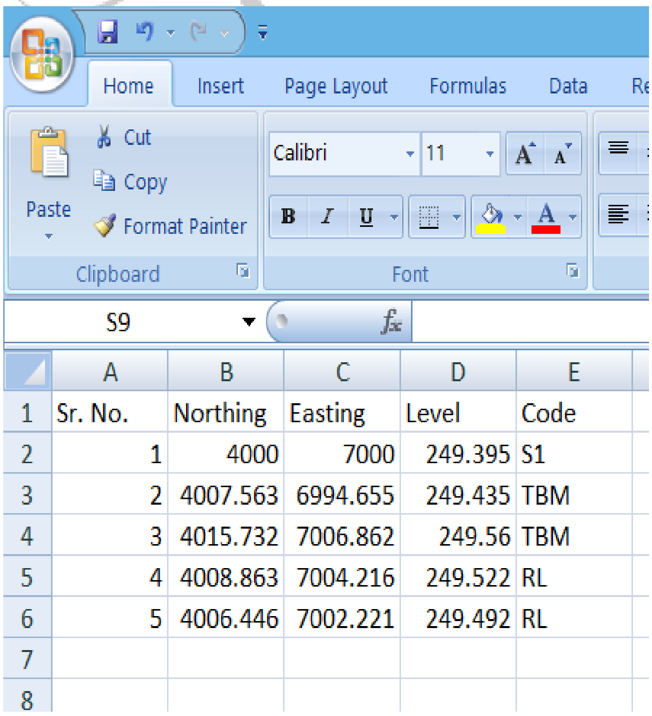
### 4.4 PROCEDURE FOR AUTODESK CIVIL 3D SOFTWARE


**Fig 2 – Procedure of civil 3D Software**

### 4.5 DATE RECEIVING

The existing ground data is required for designing of highway geometry. This survey data includes X, Y, Z co-ordinates (i.e. Northing, Easting and Reduced Level). This data can be collected now days by using total station instrument. The data are shown below:-

**Fig. 3 Existing Ground data obtained from Total Station Instrument**



| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Sr. No. | Northing | Easting | Level | Code |
| 2 | 1 | 4000 | 7000 | 249.395 | S1 |
| 3 | 2 | 4007.563 | 6994.655 | 249.435 | TBM |
| 4 | 3 | 4015.732 | 7006.862 | 249.56 | TBM |
| 5 | 4 | 4008.863 | 7004.216 | 249.522 | RL |
| 6 | 5 | 4006.446 | 7002.221 | 249.492 | RL |
| 7 | | | | | |
| 8 | | | | | |

## 4.6 DESIGN CRITERIA

The following design criteria based on the Geometric design standards manual (IRC: SP: 20 – 2002) were assigned to the horizontal geometry of the center line and also to the profile and cross section of the roadway.

I. Design speed = 65 km/h

II. Superelevation rate = max 7%

III. Coefficient of Friction = 0.15

IV. Minimum K for sag curves = 33

V. Minimum K for crest curves = 17

VI. Roadway width = 7.5 m

VII. Carriageway width = 3.75 m

VIII. Shoulder width = 1.875 m

## 4.7 HORIZONTAL ALIGNMENT DESIGN

The horizontal alignment of a road describes its orientation and location in plan view. It consists of three geometric components, including tangents (straight sections), circular curves and transition spirals between tangents and curves. Proper design of alignment is increases the highway capacities and also improves the design speed performance.
In Excel format, survey data comprising easting, northing, and elevations was import into the Civil 3D. This produced the existing surface of the ground automatically. The alignment creation tool was used to draw the road alignment after specifying the design requirements to be applied on the alignment. Using the ' Geometry Editor ' tool, the spiral and circular curves were drawn and obtained alignment curve report.
The minimum curve radius was calculated in equation (1) based on the superelevation, design speed and coefficient of friction specified in the design criteria

$$R = \frac{V2}{127(e+\mu)}$$

Where

R = minimum radius of horizontal curve in meters.
v = minimum design speed, Km/h.
e = superelevation.
f = coefficient of friction.

**Fig.4: Horizontal Alignment generated by Civil 3D**

## 4.8 VERTICAL ALIGNMENT DESIGN

Vertical alignment is defined as the longitudinal section of the road. It consists of vertical curves and gradients, it also influence the comfort in vehicles movement at high speeds, sight distance and stopping distance. When the horizontal alignment is fixed, vertical alignment can then be created. To do this, first the horizontal alignment ground profile is developed and then the vertical alignment is produced on the perspective of the profile. Profile geometry was chosen by applying minimum K design standards for vertical curves of sag and crest that meet the basic prerequisites for stopping sight distance, accessibility and appearance criteria.
Vertical curve lengths were also calculated manually using the formula (2)

$$L=KA \qquad (2)$$

Where
K= length required for a 1% change of grade.
L = vertical curve length.
A = change of grade in %.

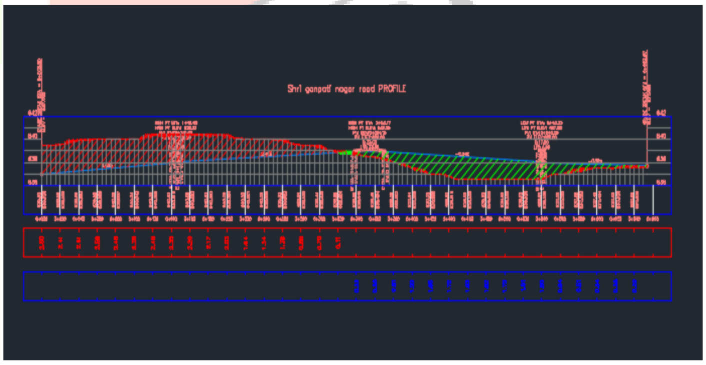


**Fig. 5: Vertical alignment generated by Civil 3D**

## 4.9 DECISION OF SUPERELEVATION

Superelevation is the transverse slope offered to counteract the centrifugal force effect and decrease the vehicle tendency to overturn and skid laterally outward by raising the pavement's outer edge toward the inner edge. Superelevation is described after the horizontal curve radius is determined. Superelevation is applied to the alignment segment via the command "Edit Superelevation."

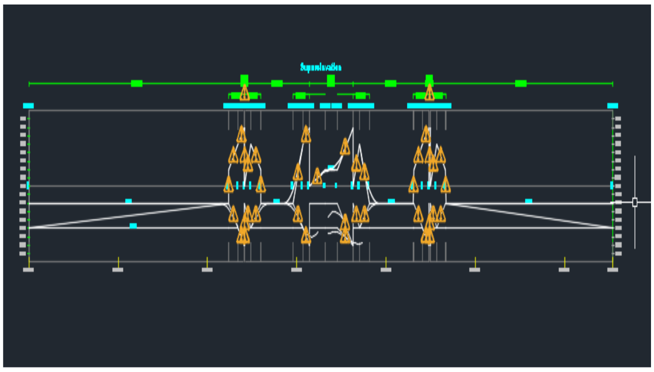


**Fig.6: Superelevation View**

### 4.10 ASSEMBLIES

Assembly is used for defining of platform in Civil 3D Software. „Subassembly" command is a part of platform, Assembly that indicates such as shoulder, median, lane for creating typical cross section of road. Right and left parts are added center of platform with subassemblies. There are two probabilities for creating assembly as using existed subassemblies or creating subassemblies by oneself.

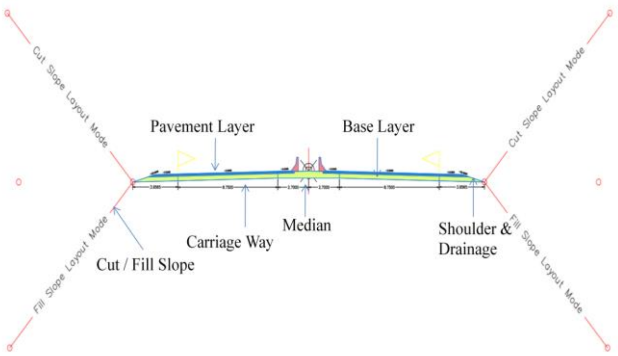



**Fig. 7. Creating Road Assembly in Autodesk Civil 3D**

### 4.11 PAVEMENT ANALYSIS

Pavements are usually classified as rigid and flexible. Rigid pavements are typically built of Portland cement concrete. In the other side, flexible pavements surface is typically made of bituminous materials in such a way that Stay in touch with the underlying substrate even though small deviations arise. Flexible Pavement is usually made up of a bituminous base underlay with a granular content overlay and an appropriate combination of coarse and fine materials. Traffic loads were transferred from the surface to that of the underlying assisting materials through the interlocking to aggregates, the frictional influence of granular materials and the cohesion of fine materials. Flexible pavements are also classified into three sub-groups: large form, moderate style and low form. High style pavements have surfaces that sufficiently bear the planned traffic load without noticeable discomfort due to exhaustion and are not prone to weather conditions. The intermediate form of pavement has a coating that varies from the coating handled to those with a consistency far below that of the strong level of pavement.

In the study considered a design of rigid pavement Criteria for Design of Rigid Pavement are based upon Axle Load spectrum obtained from Axle load data.

First, confirm that you have the correct template for your paper size. This template has been tailored for output on the A4 paper size. If you are using US letter-sized paper, please close this file and download the Microsoft Word, Letter file.

Carriageway Type: Two Lane Paved Shoulder
Design Life – 30 Years

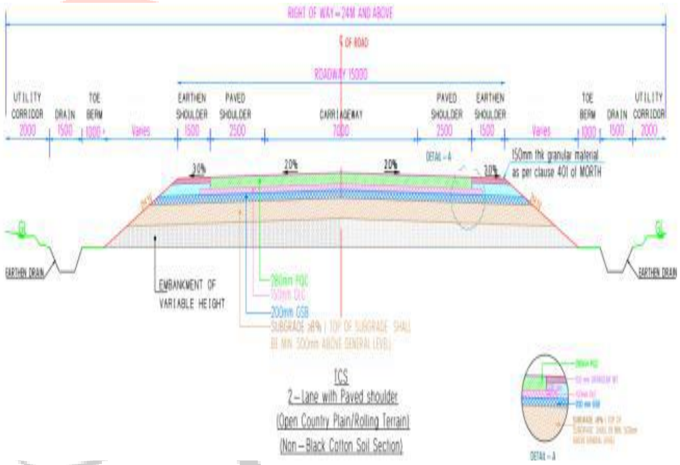
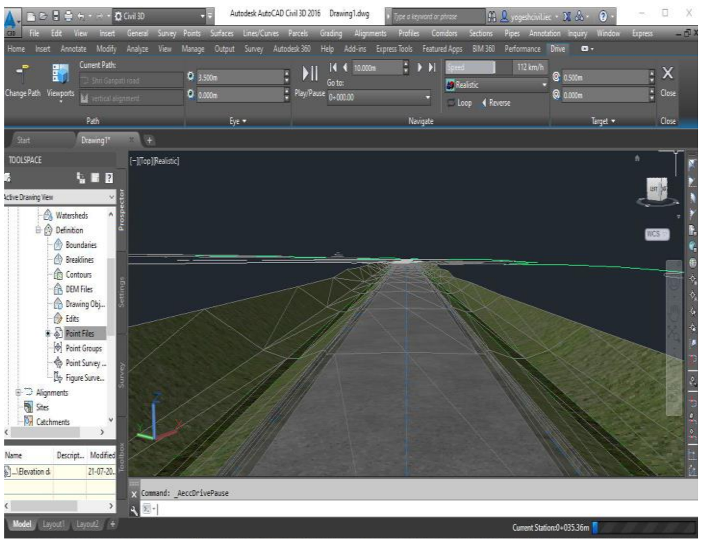


**Fig. 8. Typical Cross Section consider of study corridor**



## 4.12 CUT AND FILL CALCULATION

A feature within AutoCAD Civil 3D allows to calculate the earthwork required on a project within a few seconds. After generating the ground surface and the suggested completed grade surface, AutoCAD Civil 3D makes it simple to generate a comparison surface that highlights the difference in elevation and calculates the volume between the two surfaces. The earthwork calculation process begins by clicking ' Surfaces ' on the Modify tab.

| Station | Cut Area (Sq.m.) | Cut Volume (Cu.m.) | Reusable Volume (Cu.m.) | Fill Area (Sq.m.) | Fill Volume (Cu.m.) | Cum. Cut Vol. (Cu.m.) | Cum. Reusable Vol. (Cu.m.) | Cum. Fill Vol. (Cu.m.) | Cum. Net Vol. (Cu.m.) |
|---|---|---|---|---|---|---|---|---|---|
| 0+000.000 | 47.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0+020.000 | 47.87 | 957.46 | 957.46 | 0.00 | 0.00 | 957.46 | 957.46 | 0.00 | 957.46 |
| 0+040.000 | 48.67 | 965.39 | 965.39 | 0.00 | 0.00 | 1922.85 | 1922.85 | 0.00 | 1922.85 |
| 0+060.000 | 50.28 | 989.54 | 989.54 | 0.00 | 0.00 | 2912.40 | 2912.40 | 0.00 | 2912.40 |
| 0+080.000 | 49.10 | 993.86 | 993.86 | 0.00 | 0.00 | 3906.26 | 3906.26 | 0.00 | 3906.26 |
| 0+100.000 | 46.49 | 955.93 | 955.93 | 0.00 | 0.00 | 4862.18 | 4862.18 | 0.00 | 4862.18 |
| 0+120.000 | 48.07 | 945.60 | 945.60 | 0.00 | 0.00 | 5807.78 | 5807.78 | 0.00 | 5807.78 |
| 0+140.000 | 45.32 | 933.87 | 933.87 | 0.00 | 0.00 | 6741.65 | 6741.65 | 0.00 | 6741.65 |
| 0+160.000 | 43.64 | 889.60 | 889.60 | 0.00 | 0.00 | 7631.25 | 7631.25 | 0.00 | 7631.25 |
| 0+180.000 | 40.42 | 840.62 | 840.62 | 0.00 | 0.00 | 8471.87 | 8471.87 | 0.00 | 8471.87 |
| 0+200.000 | 38.25 | 786.73 | 786.73 | 0.00 | 0.00 | 9258.60 | 9258.60 | 0.00 | 9258.60 |
| 0+220.000 | 32.88 | 711.35 | 711.35 | 0.00 | 0.00 | 9969.95 | 9969.95 | 0.00 | 9969.95 |
| 0+240.000 | 29.84 | 627.21 | 627.21 | 0.00 | 0.00 | 10597.17 | 10597.17 | 0.00 | 10597.17 |
| 0+260.000 | 24.39 | 542.28 | 542.28 | 0.00 | 0.00 | 11139.44 | 11139.44 | 0.00 | 11139.44 |
| 0+280.000 | 17.17 | 415.52 | 415.52 | 0.00 | 0.00 | 11554.96 | 11554.96 | 0.00 | 11554.96 |
| 0+300.000 | 12.65 | 298.16 | 298.16 | 0.00 | 0.00 | 11853.12 | 11853.12 | 0.00 | 11853.12 |
| 0+320.000 | 6.13 | 187.86 | 187.86 | 0.61 | 6.00 | 12040.99 | 12040.99 | 6.00 | 12034.99 |
| 0+340.000 | 2.17 | 83.26 | 83.26 | 0.46 | 10.21 | 12124.25 | 12124.25 | 16.21 | 12108.04 |
| 0+360.000 | 0.10 | 22.83 | 22.83 | 2.26 | 26.57 | 12147.08 | 12147.08 | 42.78 | 12104.30 |
| 0+380.000 | 0.00 | 0.99 | 0.99 | 6.55 | 87.94 | 12148.07 | 12148.07 | 130.72 | 12017.35 |
| 0+400.000 | 0.00 | 0.00 | 0.00 | 13.72 | 202.72 | 12148.08 | 12148.08 | 333.44 | 11814.64 |

**Fig 9 : Earthwork Volume Report**

## 4.13 PERSPECTIVE VIEW USING DRIVE COMMAND

Select Drive command in Analyze menu and select your alignment, Feature line. Adjust the parameters and select play/pause button to drive through the corridor.

**Fig.10 : Perspective view**

## 5. RESULT AND CONCLUSION

1. The geometry of the road was intended in accordance with the IRC and also regarded all safety measures.

2. Horizontal alignment was created. Vertical profile was drafted. Working cross section is being created.

3. AutoCAD Civil 3D enables to finish the design process in a relaxed and comfortable manner in time and also maintains a lot of time and effort.

4.Superelevation was calculated and implemented.

5. The capacities of AutoCAD Civil 3D eliminate the significant disadvantages of a manual design strategy that is cumbersome, time-consuming and extremely susceptible to expensive mistakes.

6. Highways Geometric design with the help of AutoCAD civil 3D can be said to be extremely useful and also user-friendly for a three-dimensional roadway design.

7. AutoCAD Civil 3D supports design checks for different codes and thus provides global platform for design and analysis

8. The use of AutoCAD Civil 3D for highway geometric design makes the design process to be completed within a very short time and with much ease and amazing precision.

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